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NATIONAL EUTROPHICATION SURVEY

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Report
on
Whitefish Lake
Flathead County
Montana
EPA Region VIII
Working Paper No. 804

With the cooperation of the
Montana Department of Health & Environmental Sciences
and the
Montana National Guard
May, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impacts on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U.S. Environmental Protection Agency) express sincere appreciation to the Montana Department of Health and Environmental Sciences for professional involvement, to the Montana National Guard for conducting the tributary sampling phase of the Survey, and to those Montana wastewater treatment plant operators who voluntarily provided effluent samples.

The staff of the Water Quality Bureau provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General John J. Womack, the Adjutant General of Montana, and Project Officer Major William Yeager, who directed the volunteer efforts of the Montana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES AND RESERVOIRS

STATE OF MONTANA

LAKE NAME	COUNTY
Canyon Ferry	Broadwater, Lewis and Clark
Clark Canyon	Beaverhead
Flathead	Flathead, Lake
Georgetown	Deer Lodge, Granite
Hebgen	Gallatin
Koocanusa	Lincoln, MT; British Columbia, Can.
Mary Ronan	Lake
McDonald	Flathead
Nelson	Phillips
Seeley	Missoula
Swan	Lake
Tally	Flathead
Tiber	Liberty, Toole
Tongue River	Big Horn
Whitefish	Flathead
Yellowtail	Carbon, Bighorn, MT; Bighorn, WY

WHITEFISH LAKE
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Scale
Km.
Mi.
Upper Whitefish Lake
WHITEFISH LAKE
Beaver Creek
Beaver Lake
Whitefish
Mont.
Map Location
48 40
48 30
114 40
114 30
114 20

WHITEFISH LAKE

STORET NO. 3016

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Whitefish Lake is oligotrophic. It ranked first in overall trophic quality when the 15 Montana lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. One of the water bodies had less and one had the same median total phosphorus, one had less median dissolved orthophosphorus, none of the others had less but four had the same median inorganic nitrogen, two had less mean chlorophyll a, and three had greater mean Secchi disc transparency. No depression of dissolved oxygen occurred at depths as great as 51.8 meters.

Survey limnologists observed a few emergent aquatic plants near the Swift Creek inlet and the outlet in June.

B. Rate-Limiting Nutrient:

Due to significant nutrient changes in the samples, the algal assay results are not considered representative of conditions in the lake at the times of sampling.

The lake data indicate nitrogen limitation in June and phosphorus limitation in July and September.

C. Nutrient Controllability:

1. Point sources--No known wastewater treatment plants impacted Whitefish Lake during the sampling year. Lakeshore septic tanks were estimated to have contributed 0.9% of the total phosphorus load, but a shoreline survey would have to be done to

* See Appendix A.

determine the significance of those sources.

The present phosphorus loading of 0.43 g/m^2/yr is less than that proposed by Vollenweider (Vollenweider & Dillon, 1974) as a eutrophic loading (see page 11). It is likely that any significant increase in the phosphorus loading would result in a noticeable degradation of water quality, and every effort should be made to limit phosphorus inputs to the lake.

2. Non-point sources--It is estimated that non-point sources contributed nearly all of the total phosphorus load to the lake during the sampling year. Swift Creek contributed 70.6%, the minor tributaries and immediate drainage contributed an estimated 18.1%, and Lazy Creek contributed about 6% of the total load.

The phosphorus export rate of unimpacted Swift Creek was a relatively high 21 kg/km^2/yr compared to the mean export rate of 37 Montana tributaries gaged and sampled during the Survey (8 kg/km^2/yr). The cause of the higher rate is not known; however, unimpacted McDonald Creek* also had a rather high export rate (26 kg/km^2/yr), and the entire drainage of that stream is within Glacier National Park.

* See Working Paper No. 797.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 13.56 kilometers^2.
2. Mean depth: 32.9 meters.
3. Maximum depth: 62.5 meters.
4. Volume: 446.124 x 10^6 m^3.
5. Mean hydraulic retention time: 2.5 years.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Lazy Creek	43.5	0.79
Swift Creek	198.1	3.48
Minor tributaries & immediate drainage -	70.6	1.30
Totals	312.2	5.57

2. Outlet -

Whitefish River	325.8**	5.57**

C. Precipitation***:

1. Year of sampling: 73.6 centimeters.
2. Mean annual: 75.3 centimeters.

† Table of metric conversions--Appendix B.
†† Norpestad, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976.
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Whitefish Lake was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 39.6 meters at station 1, 50.6 meters at station 2, and 51.8 meters at station 3.

The sampling results are presented in full in Appendix B and are summarized in the following table.

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
06/02/75	1. Fragilaria sp.	459
	2. Synedra sp.	216
	3. Stephanodiscus sp.	86
	4. Asterionella sp.	86
	5. Chroomonas sp.	86
	Other genera	2
	total	735
07/28/75	1. Fragilaria sp.	524
	2. Dinobryon sp.	489
	3. Asterionella sp.	105
	4. Cryptomonas sp.	70
	5. Scenedesmus sp.	70
	Other genera	174
	total	1,432
09/05/75	1. Dinobryon sp.	314
	2. Sphaerocystis sp.	140
	3. Schroederia sp.	35
	total	489

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (ug/l)
06/02/75	1	1.1
	2	1.9
	3	1.9
07/28/75	1	0.9
	2	0.9
	3	1.1
09/05/75	1	1.4
	2	1.0
	3	2.4

C. Limiting Nutrient Study:

Significant changes in nutrient levels in the samples occurred prior to the beginning of the algal assays, and the results are not considered representative of conditions in the lake at the times the samples were collected (06/02/75 and 09/05/75).

The lake data indicate nitrogen limitation in June (the mean inorganic nitrogen/orthophosphorus ratio was 4/1) but phosphorus limitation in July and September (the mean N/P ratios were 14/1 and 21/1, respectively).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Montana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of May and June when two samples were collected. Sampling was begun in October, 1974, and was completed in July, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Montana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in kg/km^2/year, at stations E-1 and D-1 and multiplying the means by the ZZ area in km^2.

No known wastewater treatment plants impacted Whitefish Lake during the sampling year.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr.	% of total
a. Tributaries (non-point load) -		
Lazy Creek	375	6.4
Swift Creek	4,130	70.6
b. Minor tributaries & immediate drainage (non-point load) -	1,060	18.1
c. Known municipal STP's - None	-	-
d. Septic tanks* -	55	0.9
e. Known industrial - None	-	-
f. Direct precipitation** -	235	4.0
Total	5,855	100.0

2. Outputs -

Lake outlet - Whitefish River 2,580

3. Net annual P accumulation - 3,275 kg.

* Estimate based on 198 lakeshore dwellings and one park, see Working Paper No. 175.

** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Lazy Creek	16,485	10.3
Swift Creek	95,660	60.1
b. Minor tributaries & immediate drainage (non-point load) -	30,430	19.1
c. Known municipal STP's - None	-	-
d. Septic tanks* -	2,145	1.3
e. Known industrial - None	-	-
f. Direct precipitation** -	14,640	9.2
Total	159,360	100.0

2. Outputs -

Lake outlet - Whitefish River	87,710

3. Net annual N accumulation - 71,650 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Lazy Creek	9	379
Swift Creek	21	483

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Beaver Creek	0.012	0.641
Hell Roaring Creek	0.014	0.558

* Estimate based on 198 lakeshore dwellings and one park; see Working Paper No. 175.
** See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.43	0.24	11.8	5.3

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Whitefish Lake:

"Dangerous" (eutrophic loading)	0.70
"Permissible" (oligotrophic loading)	0.35

V. LITERATURE REVIEWED

Horpestad, Abe, 1975. Personal communication (lake morphometry). MT Dept. of Health & Env. Sci., Helena.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

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APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

APPENDIX D

PHYSICAL and CHEMICAL DATA

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APPENDIX E

TRIBUTARY DATA

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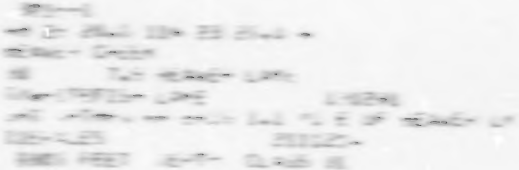

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